Journal of Cranio-Maxillo-Facial Surgery 42 (2014) 1730–1734

Contents lists available at ScienceDirect

Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

Changes of the retrolingual pharynx during the Muller manoeuvre and during sleep in sleep apnoea

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ARTICLE INFO

Article history:
Paper received 12 January 2014
Accepted 5 June 2014
Available online 13 June 2014

Keywords:
Obstructive sleep apnoea
Sleep endoscopy
Muller manoeuvre

ABSTRACT

Objective: To determine whether the retrolingual pharynx shows the same morphometric modifications during the Muller manoeuvre and during drug-induced sleep endoscopy (DISE) with propofol in patients submitted for maxillomandibular advancement surgery.
Subjects and methods: Eighteen patients submitted for maxillomandibular advancement surgery (MMAS) were evaluated endoscopically before and 6 month after surgery in the region of the retrolingual pharynx while seated and lying in dorsal decubitus (supine) while performing the Muller manoeuvre and during DISE with propofol, to verify and measure if the same morphometric changes occur in the retrolingual pharynx during the Muller manoeuvre and during DISE with propofol. The area, anteroposterior, and laterolateral retrolingual pharynx images were acquired using the Sony Vegas 8.0 software and recorded on a DVD. The Image J software was used to measure and compare these images.
Results: An increase in the pharyngeal aperture was observed in all measurements after surgery, specifically in area retrolingual pharynx images. When the Muller manoeuvre was performed, a greater gain (113%) in area retrolingual pharynx measurement was observed when the patient was awake and seated. With the patient was in dorsal decubitus during DISE with propofol there was a greater gain in area retrolingual pharynx measurement (201.33%) in the smaller aperture.
Conclusion: The Muller manoeuvre after MMAS does not simulate the dimensions of the pharynx that occur during sleep.

1. Introduction

The measurement of the volume and location of the site of pharyngeal obstruction in patients with obstructive sleep apnoea syndrome (OSAS) has been traditionally considered as problematical (Moore and Phillips, 2002). The difficulties in properly measuring the pharynx are largely caused by the morphometric changes due to the position, respiration and state of consciousness of the individual (Woodson and Naganuma, 1999).

Regardless of the evaluation modality used, several studies have tried to identify the sites where a reduction or obstruction of the pharynx may occur, but the data obtained have been inconsistent (Crumley et al., 1987; Chaban et al., 1988; Croft and Pringle, 1991; Aboussouan et al., 1995; Connolly et al., 1994; Woodson and Naganuma, 1999; Higami et al., 2002; Hsu, 2002; Li et al., 2002; Moore and Phillips, 2002; Rama et al., 2002; Hessel and Vries, 2003; Hsu et al., 2004; Mello-Filho et al., 2006; Rabelo et al., 2010).

In 1983 Borowiecki and Sassi introduced nasofibrolaryngoscopy with the Muller manoeuvre and this method has been considered by some authors to be appropriate for the identification of pharyngeal narrowing or obstruction in patients with OSAS (Borowiecki and Sassin, 1983).

Several limitations of the Muller manoeuvre have been described (Thorpy et al., 1985; Katsantonis et al., 1989, Petri et al., 1994; Terris et al., 2000). However, maxillomandibular

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http://dx.doi.org/10.1016/j.jcms.2014.06.007
1010-5182/

advancement surgery (MMAS) has shown good results by producing a significant enlargement of the pharynx, with a reduction or even the disappearance of OSAS (Croft and Pringle, 1991; Rama et al., 2002; Mello-Filho et al., 2012).

Although patients with OSAS are well known to present a narrowed or obstructed pharynx during sleep and during the Muller manoeuvre, the modifications occurring in these patients after MMAS have not been fully established. Does the enlargement of the pharynx with MMAS prevent or improve the narrowed or obstructed pharynx in an identical manner during sleep and during the Muller manoeuvre?

The objective of the present study was to determine, before and after surgery, whether patients with OSAS submitted to MMAS presented the same morphometric changes in the retrolingual pharynx during the Muller manoeuvre and during drug-induced sleep endoscopy (DISE) with propofol.

2. Materials and methods

The study was approved by the Research Ethics Committee of the University Hospital, Faculty of Medicine of Ribeirão Preto, University of São Paulo (HCFMRP-USP) (protocol n° 10326/2008). All patients provided their written informed consent to participate in the study. Eighteen patients with an average age of 47.61 ± 9.01 years, seen at the HCFMRP-USP, including 13 males (72.22%) and 5 females (27.77%) with mild to severe OSAS determined by polysomnography, were studied. All patients received nasofibrolaryngoscopy with the Muller manoeuvre followed by DISE with propofol. The examinations were performed preoperatively and 6 months after surgery.

Patients were excluded from this study when they presented with co-morbidities that would contraindicate surgical intervention, when they could not be submitted to the exams listed in the protocol, when they did not accept to participate in the study, and when they did not execute all the pre- and postoperative exams.

The anatomical and functional characteristics of the pharynx were evaluated before and 6 months after MMAS in order to determine whether the same morphometric modifications of the retrolingual pharynx occurred during the Muller manoeuvre and during DISE with propofol. An emphasis was placed on the level of the tongue base (retrolingual), with images being acquired for area, linear anteroposterior and laterolateral measurements of the pharynx (see Fig. 1). The clinical history of the patients was obtained both before and after surgery, and the subjects were submitted to physical examination, polysomnography and nasofibrolaryngoscopy while awake with the use of the Muller manoeuvre and during DISE with propofol.

All nasofibrolaryngoscopy procedures were performed by the same examiner. The patients were evaluated while awake, seated and in dorsal decubitus (supine) and during DISE with propofol. The results were compared in order to determine whether the morphological patterns of patients with OSAS submitted to MMAS showed the same morphometric modifications of the retrolingual pharynx during the Muller manoeuvre and during DISE with propofol.

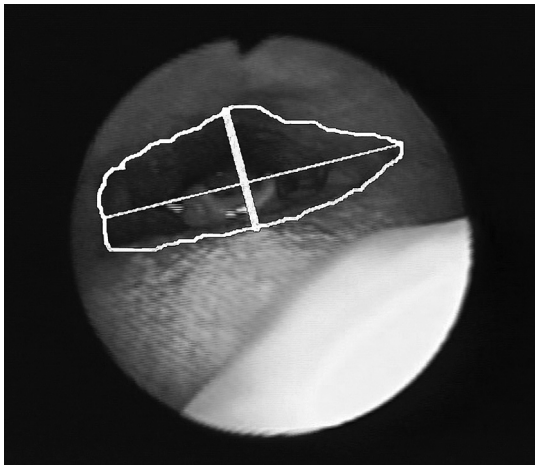

Fig. 1. Measurements of the pharynx obtained: area (circle), linear anteroposterior measurement (thick line) and linear laterolateral measurement (thin line).

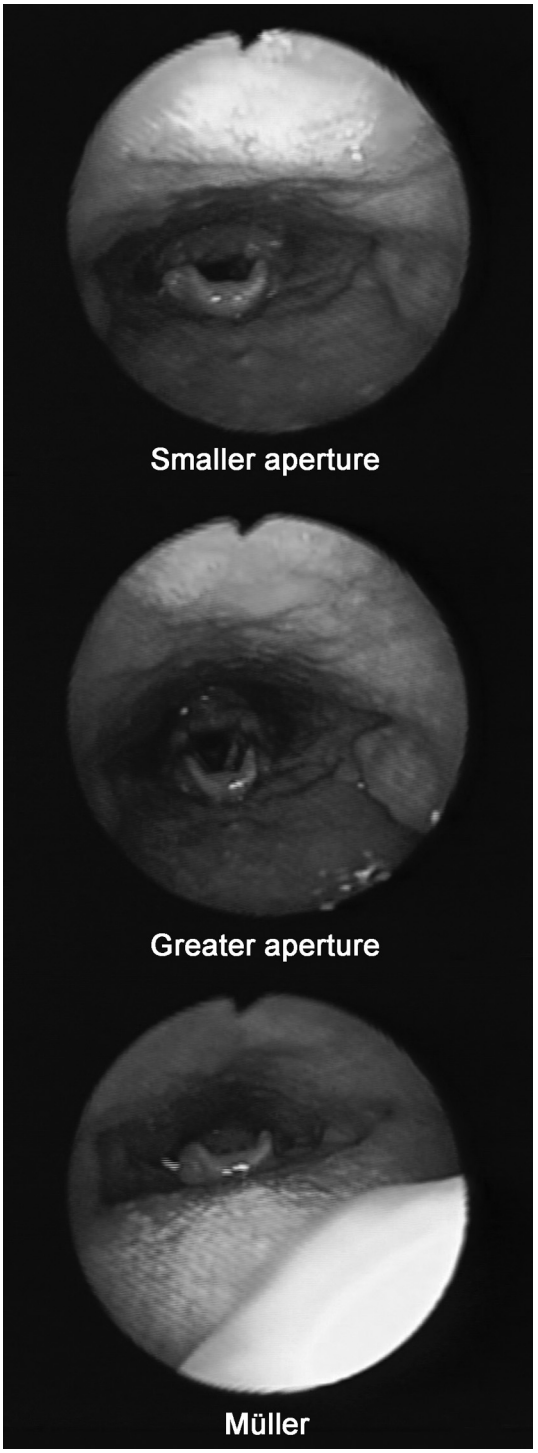

Fig. 2. Acquired images. Preoperative evaluation and nasofibrolaryngoscopy with the patient awake and in the dorsal decubitus position.

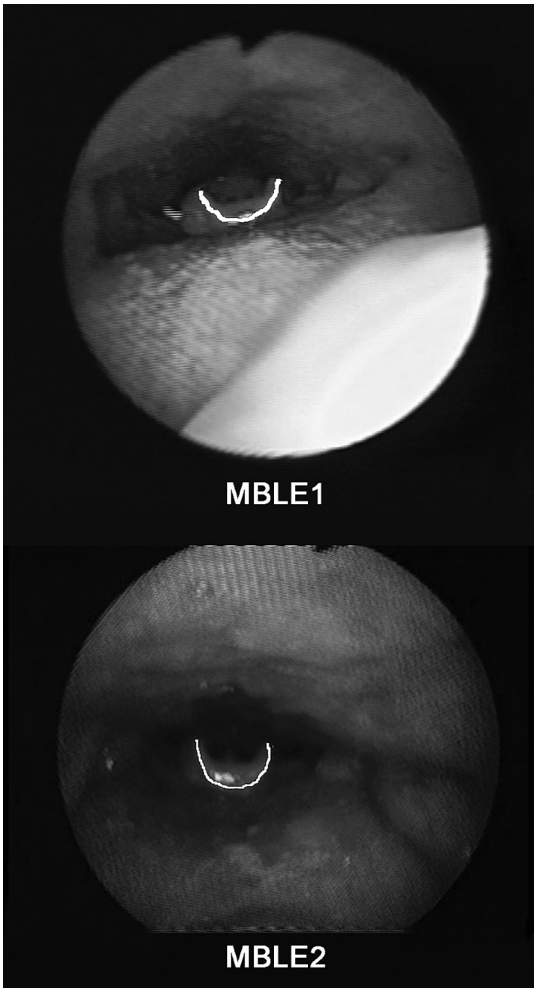

Fig. 3. Correction factor: measurement of the free epiglottis margin (MFEM). Example of an image acquired preoperatively (MFEM1) and an image acquired postoperatively (MFEM2).

2.1. Nasofibrolaryngoscopy during wakefulness with the use of the Muller manoeuvre and during DISE with propofol

The patients were examined while awake and seated and in dorsal decubitus. Cotton wool soaked with a topical nasal anaesthetic, 2% neotutocaine, and a nasal decongestant was placed in the nasal cavity and left there for about 10 min. A 7 mm Olympus BF, Type 1T30 flexible nasopharyngoscope (Olympus Medical Systems Corp., Hachioji-shi, Tokyo, Japan) coupled to a Storz-Endoskope Dx-Cam NTSC microcamera, model 202301 20 (Karl Storz Imaging, Goleta, CA, USA) was introduced through the nostril towards the larynx until it went beyond the soft palate, to providing an ample view of the oro- and hypopharynx.

The collapses of the wall at the base of the tongue was analysed by forced inspiration using the Muller manoeuvre. The Muller manoeuvre was performed by the examiner who closed the nasal cavity and the mouth of the patient while the patient was seated and in the dorsal decubitus positions. For a better standardization of inspiration force during the Muller manoeuvre, the patient was instructed to make the greatest possible effort in the same manner in the seated and dorsal decubitus positions. Additionally, the manoeuvre was repeated at least three times both pre- and postoperatively. This eliminated the possibility of different efforts among individuals, permitting a more faithful observation of only the gain obtained after MMAS. However, nasofibrolaryngoscopy during DISE with propofol was performed only in dorsal decubitus.

The patients were then submitted to DISE with propofol while being continuously monitored by the same anaesthesiologist. Basic monitoring was performed using a pulse oximeter, noninvasive determination of blood pressure and cardioscopy to determine the cardiac rhythm. Propofol (40–50 mg) was used every 20 s until the palpebral reflex was gone. Additional propofol amounts of 25–50 mg were administered as needed (i.e., when sleep became superficial), as revealed by the patient's uncomfortable reaction to the device.

2.2. Image acquisition and measurement

All nasofibrolaryngoscopy examinations were recorded on a DVD. The images were acquired before and after surgery using the Sony Vegas 8.0 software (Sony Creative Software, Madison, WI, USA) with the patient in a predetermined position immediately after the nasofibrolaryngoscope had moved beyond the soft palate, with a broad view of the retrolingual region. The images were measured and evaluated in megapixels using the Image J software (produced by Wayne Rasband, United States National Institutes of Health, Bethesda, MD, USA), with the patient awake, seated and in dorsal decubitus, and lying in dorsal decubitus during DISE with propofol.

The following images were acquired (see Fig. 2):

- smaller aperture: corresponding to the image of the smaller aperture of the pharynx during natural breathing, including in the presence of complete obstruction.

Table 1
Results comparing the pre- and postoperative images: Muller, smaller aperture and greater aperture in the awake and seated position (Position 1), awake and dorsal decubitus (Position 2) and dorsal decubitus during DISE with propofol (Position 3). The estimated difference in the means, the *P*-value, 9% confidence limits: lower limit (LL) and upper limit (UL) were calculated.

Variable	Type of measurement	Comparisons	Estimate of the mean difference	*P*-value	95% confidence interval	
					LL	UL
Muller	Area	Position 1	−52557.00	0.01	−67088.00	−38026.00
		Position 2	−51041.00	0.01	−65572.00	−36509.00
	Linear anteroposterior	Position 1	−91.03	0.01	−128.17	−53.88
		Position 2	−101.57	0.01	−138.72	−64.43
	Linear laterolateral	Position 1	−61.90	0.02	−115.02	−8.79
		Position 2	−76.29	0.01	−129.41	−23.18
Smaller aperture	Area	Position 3	−70200.00	0.01	−86752.00	−53647.00
	Linear anteroposterior	Position 3	−178.95	0.01	−225.29	−132.60
	Linear laterolateral	Position 3	−180.02	0.01	−247.40	−112.64
Greater Aperture	Area	Position 3	−64726.00	0.01	−88121.00	−41331.00
	Linear anteroposterior	Position 3	−132.72	0.01	−192.55	−72.90
	Linear laterolateral	Position 3	−111.99	0.01	−196.28	−27.70

- greater aperture: corresponding to the image of the greater aperture of the pharynx during natural breathing.
- Muller: corresponding to the image of greater collapse during the performance of the Muller manoeuvre, i.e., closure of the nasal cavity by the examiner and of the mouth by the patient himself, who was then asked to perform a forced inspiration.

The following measurements were taken for each acquired image (see Fig. 1):

- area: measurement of the pharyngeal lumen above the epiglottis limited by the posterior and lateral walls of the pharynx and by the tongue base anteriorly.
- linear anteroposterior: linear measurement of the pharyngeal lumen above the epiglottis between the posterior wall and the tongue base.
- linear laterolateral: linear measurement of the pharyngeal lumen above the epiglottis between the lateral walls.

The nasofibrolaryngoscopy images during DISE with propofol were acquired for the smaller and greater aperture.

In order to obtain identical images, a correction factor was applied using the measurement of the free epiglottis margins (MFEM) in megapixels in order to account for the variable distance between the fibroscope and the area under study (see Fig. 3). Because the free margin of the epiglottis is cartilaginous and only has a slightly deformable anatomical structure, its measurement obtained on the image acquired preoperatively (MFEM1) was divided by the MFEM acquired postoperatively (MFEM2). Thus, when the images were compared, the correction factor was applied in to make the two lines of the margin epiglottis of equal size, so that the remaining measurements could also be compared using the same scales.

3. Results

The results obtained were compared in order to determine whether patients with OSAS who were submitted to MMAS showed the same morphometric modifications of the retrolingual pharynx during the Muller manoeuvre and during DISE with propofol. The images were acquired and measured with a correction factor for their direct comparison.

During DISE with propofol, the nasofibrolaryngoscopy images were acquired in the smaller and greater apertures with the patient lying in dorsal decubitus.

An increase in the pharyngeal aperture was also observed in all measurements when the patients were compared before and after surgery, awake and seated during the execution of the Muller manoeuvre, awake and in dorsal decubitus during the execution of the Muller manoeuvre, and in dorsal decubitus during DISE with propofol (Tables 1–5). Taken together, the present findings demonstrate that the volume of the pharynx always increased significantly for all measurements after MMAS.

When the patients were compared pre- and postoperatively, awake and seated and awake in dorsal decubitus during the Muller manoeuvre, an increase in the pharyngeal aperture was observed for all measurements. This increase was more extensive when the Muller manoeuvre was performed with the patient awake and seated. Specifically, the greatest postoperative gain of 113% occurred in the area measurement during the Muller manoeuvre with the patient awake and seated (Tables 2 and 3). The anteroposterior and laterolateral dimensions also increased in all their measurements after surgery, with the patient awake and seated or in dorsal decubitus during the Muller manoeuvre.

The area measurement was the most important variable to be observed. There was a significant increase in the area measurement in the smaller pharynx aperture in patients in dorsal decubitus and during DISE with propofol, with a 201.33% gain (Table 5). A greater gain of the anteroposterior and laterolateral dimensions, which also occurred in the smaller pharynx aperture, were 124.90% and 76.59%, respectively (Table 5).

Table 1 shows the results of the comparison of the pre- and postoperative images: Muller manoeuvre, smaller pharynx aperture and greater pharynx aperture, and for the following types of measurements: area, linear anteroposterior and linear laterolateral, in the awake and seated position (position 1), awake and dorsal decubitus (position 2) and dorsal decubitus during DISE with propofol (position 3). The estimated difference in the means, the *P*-value, 9% confidence limits: lower limit (LL) and upper limit (UL) were calculated.

Table 2 shows the percent difference in the values obtained pre- and postoperatively with the patient awake and seated while executing the Muller manoeuvre.

Table 3 shows the percent difference in the values obtained pre- and postoperatively with the patient awake and in dorsal decubitus while executing the Muller manoeuvre.

Table 4 presents the percent difference of the values obtained with the patients in dorsal decubitus during DISE with propofol in the pre- and postoperative comparison.

Table 5 shows the percent difference in the values of the smaller and greater aperture obtained with the patient awake and seated and executing the Muller manoeuvre, awake and in dorsal decubitus, and during DISE with propofol.

Table 2
Percent difference in the preoperative and postoperative values obtained with the patients awake and seated and executing the Muller manoeuvre.

Variable	Type of measurement	Awake seated		
		Preoperative	Postoperative	% Difference
Müller	Area	46159.89	98716.77	113.85
	Linear anteroposterior	213.77	304.79	42.57
	Linear laterolateral	299.22	361.12	20.68

Table 3
Percent difference in the preoperative and postoperative values obtained with the patients awake and in dorsal decubitus and executing the Muller manoeuvre.

Variable	Type of measurement	Awake in dorsal decubitus		
		Preoperative	Postoperative	% difference
Müller	Area	55256.22	106296.78	92.37
	Linear anteroposterior	237.85	339.42	42.70
	Linear laterolateral	309.47	385.76	24.65

4. Discussion

The measurement of the pharyngeal volume and the localization of the obstruction site during sleep, i.e., the changes that occur

Table 4
Percent difference in the preoperative and postoperative values obtained with the patients in dorsal decubitus during DISE with propofol.

Variable	Type of measurement	DISE with propofol and dorsal decubitus		
		Preoperative	Postoperative	% difference
Smaller aperture	Area	34519.56	104018.27	201.33
	Linear anteroposterior	143.27	322.21	124.90
	Linear laterolateral	235.05	415.08	76.59
Greater aperture	Area	82924.72	147650.44	78.05
	Linear anteroposterior	273.93	406.66	48.49
	Linear laterolateral	401.89	513.88	27.85

Table 5
Percent difference (gain) of the values of the smaller and greater aperture obtained with the patients awake and seated executing the Muller manoeuvre, awake and in dorsal decubitus executing the Muller manoeuvre and in dorsal decubitus during DISE with propofol.

Type of measurement	% difference (gain)			
	Awake seated Muller	Awake dorsal decubitus Muller	DISE with propofol dorsal decubitus smaller aperture	DISE with propofol dorsal decubitus greater aperture
Area	113.85	92.37	201.33	78.05
Linear anteroposterior	42.57	42.70	124.90	48.49
Linear laterolateral	20.68	24.65	76.59	27.85

in the pharynx of patients with OSAS during sleep, is a highly controversial topic and traditionally considered to be problematical (Higami et al., 2002; Li et al., 2002; Moore and Phillips, 2002).

Woodson and Naganuma compared different diagnostic methods for the evaluation of the upper airways in patients with OSAS and concluded that nasofibrolaryngoscopy performed in dorsal decubitus is a promising procedure for the appropriate evaluation of the posterior airspace, especially in the retrolingual region (Woodson and Naganuma, 1999).

Importantly, the localization of the anatomical narrowing of the pharynx soft tissues using the Muller manoeuvre has been questioned due to the natural subjectivity of this exam during the performance of intraluminal negative pressure in the pharynx, which varies in terms of effort from patient to patient (Crumley et al., 1987). In order to standardize the procedure and to improve the fidelity of nasofibrolaringoscopy with the Muller manoeuvre, each patient was compared with themselves before and after surgery and not to other patients. All exams were performed by the same examiner. Our results demonstrate that the airway showed a lower reduction and greater airspace during the Muller manoeuvre (Tables 2 and 3).

In agreement with the present findings, Crumley et al. reported that all their patients showed a reduction of pharyngeal space after lying in dorsal decubitus because the tongue muscles tend to reach a posterior position due to gravity (Crumley et al., 1987). In general, a greater increase in pharyngeal aperture was observed in awake and seated patients compared to awake patients in dorsal decubitus during the Muller manoeuvre, possibly because of the fall of the tongue base occurring when an individual lies in dorsal decubitus (Tables 2 and 3).

The present study demonstrated that patients submitted for MMAS had an increase in the pharyngeal lumen in all its dimensions and that the area measurement was the most important observed variable (Tables 1–5). The area measurement observed in the acquired image showing a smaller aperture when the individual was in dorsal decubitus during DISE with propofol that presented a greater proportional increase of the pharyngeal lumen after surgery, i.e., 201.33% (Table 5). These values clearly demonstrate that MMAS prevents the collapse of the pharynx with the consequent production of OSAS and that the Muller manoeuvre does not simulate what occurs during sleep since its postoperative gain was much lower (Table 5).

These findings suggest that the improvement of both the dimension and the collapse of the pharynx can explain the high rate of success of MMAS.

5. Conclusions

The results obtained here demonstrate that the dimensions of the pharynx always increased significantly in all measurements after MMAS. However, the Muller manoeuvre does not simulate the dimensions of the pharynx that occur during sleep, since their postoperative gain was much smaller.

Financial or material support

This study received no financial or material support.

Conflict of interest

None.

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